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Proposal No. 57-177A
on
THICKNESS MEASUREMENT OF
NON-METALLIC MATERIALS



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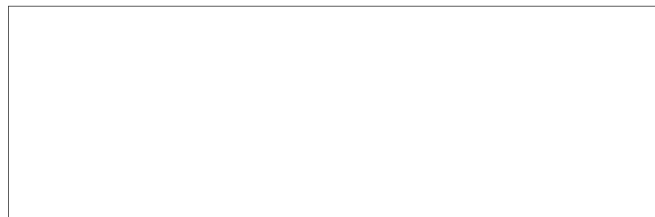
for



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Part I
(Technical Details)

Submitted by:



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THICKNESS MEASUREMENT OF NON-METALLIC MATERIALS

I. INTRODUCTION

This proposal is submitted as a result of findings on Project No. A-075. The original study involved the use of nuclear techniques employing the back scattering properties of various nuclear particles to determine the thickness of a non-metallic material. During this feasibility study a preliminary investigation was made to determine the application of ultrasonic energy for the measurement of the thickness of non-metallic materials. Both methods have shown promise for these measurements. The nuclear technique, as reported in the monthly progress reports, indicates that accuracy can be obtained for relatively thin samples (1/2" to 2"). The results of the sonic investigation are contained in a separate technical report concerning the application of sonic energy to this problem. The use of sonic energy may allow relatively accurate measurements of thicknesses as great as 2' or 3'. Certain limitations can be expected for thin samples due to the extremely short transit times involved.

This proposal is prepared to extend the work on this problem to obtain a practical solution to the measurement of thickness of non-metallic materials by the use of sonic energy. In addition, if limitations are found on the minimum thickness which can be measured further work may be accomplished using nuclear techniques to provide a combined sonic and nuclear measurement system giving accurate results for thicknesses from 1/2" to 2' or 3'. Efforts will be made, however, to develop one instrument which is capable of performing over a maximum range of thickness. The instrument to be developed under this program will not be a final small compact version but will be a working model which provides a relatively accurate simple measurement of the thickness of various materials.

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II. SUMMARY OF FEASIBILITY STUDY

The nuclear technique utilizing the back scattering properties of various nuclear particles has been studied to the extent that measurements show relatively accurate determination of sample thicknesses from 1/2" to 2". Some improvement can be obtained on the accuracy to which these measurements are made but little can be done to extend the range of measurements. The principle involved shows that a thickness of approximately 4" is detected the same as other thicknesses between 4" and infinite thickness. Better instrumentation, however, may result in a more accurate determination of thicknesses less than 4".

The preliminary investigation using sonic techniques for the measurement of thickness of various materials included a short measurement program involving the use of commercially available ultrasonic thickness measuring equipment. Measurements were made on several types of non-metallic samples, including granite, concrete, tile block and lucite. The instrumentation was limited to sound waves from 0.5 to 10 megacycles per second. Samples which are homogeneous in nature and contain small particle sizes allow for immediate application of one of the commercially available ultrasonic thickness measuring equipment. Successful measurements were made in lucite and granite providing the sample was no more than 6" thick. The measurement of thickness in less homogeneous materials such as concrete were limited by the scattering produced by particles having dimensions of the same order of magnitude as the wave length of sound.

The equipment which was available for the study was of relatively low power and was limited in versatility by fixed frequencies. Measurements were made, however, to determine the effect of frequency by measuring the transmission properties of samples of concrete. It was determined experimentally that the scattering and/or absorption of sound in concrete decreased rapidly with decreasing frequency. Indications were obtained showing that if sufficient power were introduced in a frequency range from 20 to 200 kilocycles per second that results could be obtained on concrete as well as the other materials investigated. The use of lower frequencies, however, requires larger transducers, several square inches in area, in order to produce plane wave energy.

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In conjunction with the basic measurements made with available equipment, a search of literature revealed several successful programs in the measurement of thickness of concrete. Measurements have been made of the thickness of concrete airplane runways by the use of an echo-pulse sonic technique similar to that proposed in this study. Similar measurements have been made through as much as 50 ft. of concrete in the measurement of the properties of concrete in dams. These greater distances, however, are limited only to transmission measurements for which one transducer is placed on one side and another transducer on the other side. The results of the literature survey indicate that the frequency range to be used is from 20 to 200 kilocycles per second. In order to measure relatively large thickness transducers having areas of several square inches and being more sensitive than the quartz transducers used in our investigation must be used. The echo-pulse method appears to have more advantages than the resonance techniques. However, some investigation concerning application to this particular problem should be made.

The preliminary study, therefore, indicated experimentally that successful measurements can be made on non-metallic materials. The nuclear techniques, although successful, are limited to thicknesses which are relatively small. The sonic techniques investigated show promise in the successful solution to this problem and these measurements are substantiated by several publications utilizing the same techniques to similar measurement problems.

III. PROPOSED PLAN OF RESEARCH

A. Sonic

The proposed plan of research is to concentrate effort on the application of sonic techniques to the measurement of thickness. These techniques, however, may be needed after a thorough investigation of the sonic methods in order to provide a complete solution to this problem over a required range of thicknesses. Transducers will be designed which are suitable for this particular problem and the necessary electronic apparatus will be constructed to allow for an experimental measurement

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program. After successful measurements have been made with large powerful transducers the investigation will be continued to determine the minimum size and weight of equipment which appears feasible for the accuracy which is required. The program will include a simultaneous study of the measurement of relatively large thicknesses where size of the transducer is relatively unimportant (transducer area of 4 to 10 square inches) and the measurement of small thicknesses of the order of 1 inch by relatively small transducers utilizing higher frequency sound energy.

B. Nuclear

The nuclear work to be carried out under this proposal will consist of two separate items. At the request of the sponsor additional investigations will be carried out to determine the applicability of lead radiators to detect back-scattered photons. In addition, a prototype instrument will be constructed. This instrument will be designed with field use in mind, but will not be a field device. Every effort will be made to complete the nuclear phase of the work within the period of the last time extension; that is to say, prior to February 28, 1957.

IV. ESTIMATED TIME AND EFFORT

A. Sonic

It is proposed that the sonic phases of this study have a duration of 12 months, although the measurement program in itself does not require extended periods of time limitations are expected on the progress due to the time required for acquiring special transducers and developing proper electronic circuitry which will allow for an investigation of this technique. A working model is expected to be developed during this program; however, the equipment will not be developed to the point of maximum desirability so far as field usage is concerned.

B. Nuclear

It is estimated that the additional work can be accomplished in an elapsed time of 4 months at a cost of \$5,080.00. A detailed cost estimate is included.

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VI. CONCLUSIONS

It is felt that an experimental program utilizing sonic techniques will produce a successful solution to the measurement of thickness of various materials. Although a complete solution may not be obtained by this technique a combination with nuclear techniques may provide for a successful solution to this problem. The sponsor is referred to the various progress reports and the special technical report on the use of sonic techniques to help in the evaluation of this proposal.

Respectfully submitted,

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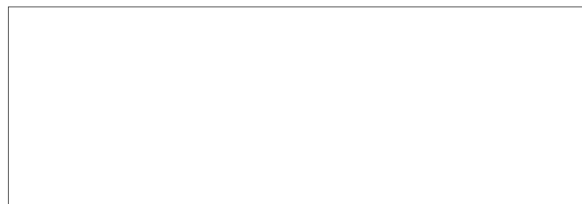
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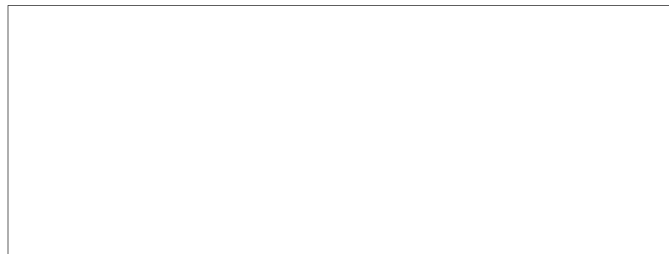
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Part II
(Cost Estimate)



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